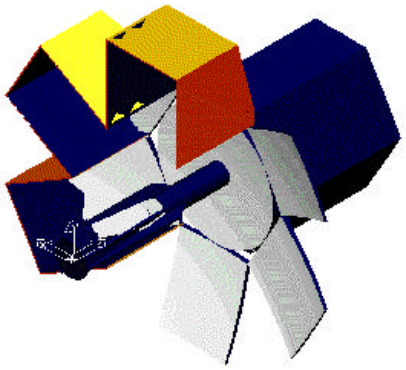
Earth Science Enterprise Technology Planning Workshop

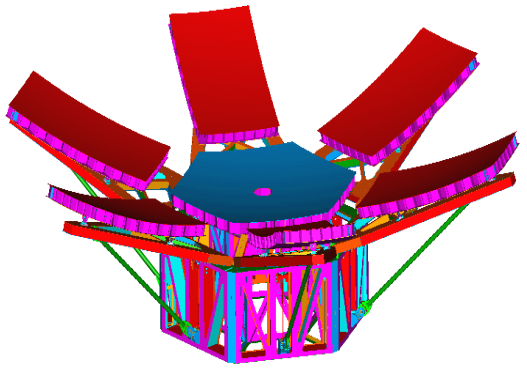
Light-Weight Deployable UV/Visible/IR Telescopes

Ed Browell (Co-Chair) - LaRC

Frank Peri (Co-Chair) - GSFC

Robert Connerton (Facilitator) GSFC





Earth Science Enterprise Technology Planning Workshop
Light-Weight Deployable UV/Visible/IR Telescopes

Agenda

Tuesday JAN 23, 2001

Presenter	Topic
Ed Browell - NASA Langley	"Active Remote Sensing of Gases and Aerosols with Deployable Telescopes".
Mike Hardesty - NOAA	“Large Aperture Telescopes for Doppler Wind Measurements”
Jeffrey Wynn - Kodak	“Precision Deployment of Optical Systems”
Fred Beavers - CTD, Inc.	“Elastic Memory Composite (EMC) Materials for Deployable Telescope Structures"
Alex Dudelzak - CSA	“UV/Visible/IR Deployable Telescope Technology for Space-Based” Lidars
Geary Schwemmer - NASA Goddard	“ Lidar Remote Sensing Instruments for Future Spaceborne Platform
Discussion	
Interim Summary of Issues	

Agenda

Wednesday, JAN 24, 2001

9:00 Identify convergence of Science needs and candidate Technology approaches
- new capabilities enabled
- reductions in implementation and life-cycle costs

Define specific capability/technology needs for each measurement class
Describe and illustrate the current state of the art for the technology
Itemize the major technology components and current technology readiness level
Identify ongoing investments
Identify technology development gaps

12:00 Lunch Break

1:00 Formulate draft technology development roadmaps
- Show key development and flight validation objectives and milestones
  - Ground development and validation needed
  - Include technology flight validation where necessary

2:45 Break

3:00 Summary Plenary Session
- 10-minute presentations by Chairs of each Breakout Session

5:00 Adjourn

Earth Science Enterprise Technology Planning Workshop

Light-Weight Deployable UV/Visible/IR Telescopes

- Focus:
  - Light weight deployable telescopes for ultraviolet, visible, and infrared wavelengths
- Technology components requiring validation:
  - High quality, light-weight optical elements, as well as deployment
  - Latching, and phasing technologies that can be scaled to enable apertures with >5 m2 reflecting area
- Intended science measurements enabled:
  - Differential absorption lidar for high vertical resolution mapping of tropospheric ozone, CO2, water vapor, NO2, and aerosols
  - Direct detection and coherent lidar observations of tropospheric winds from space
  - High resolution imaging and spectroscopic observations from high orbits (GEO, LI, and L2)

Participants

- David Mollenhauer — AFRL/MLBC
- Dennis Skelton — Orbital Sci
- Herbert Majower — Swales
- James Bremer — Swales
- Geary Schwemmer — GSFC
- Kai Matsui — NASA
- John F. Hahn — Optech Inc.
- Fran Merti — Northrop
- Bill Gail — Ball
- Steve Jones — Honeywell
- Mike Hardesty — NOAA/TL
- Ronald Leung — GSFC
- Mariann Albjerg — GSFC
- Lamant DiBiasi — L.D. Biasi Assoc
- Alex Dudelzak — Canadian Space Agency
- Ed Browell — NASA LaRC

- James O. Covington — Aerospace Corp.
- Tom Connors — U of AZ
- Fred Beavers — Composite Tech. Dev
- Bill Sharp — ITT Indust.
- Bob Connerton — NASA/ESTO
- Brian Nastvogel — Northrop Grumman
- Tosh Fujita — JPL
- Helen Boussalis — Cal State L. A.
- Naj Dean Mirmirani — Cal State L.A.
- Cal Abplanalp — Eastman Kodak
- Jeffrey Wynn — Eastman Kodak
- Frank Peri — NASA ESTO
- Bob Cassanova — NASA Inst. for Advanced Concepts

Light-Weight Deployable UV/Visible/IR Telescopes

Science Measurements Enabled

- Tropospheric Chemistry
  - High vertical resolution tropospheric O3 , NO2, and aerosol profiles
- Carbon Cycle Budget
  - Profile and column CO2 distributions
- Global Water & Energy Cycle
  - Water vapor, temperature, aerosol, & cloud distributions (active & passive combined)
  - Tropospheric winds (direct & coherent)
- Thermal IR Imaging from GEO, L1, L2
  - High spatial (horizontal) and temporal resolution for rapidly evolving regional scale processes

Deployable Telescope Tech.

- Telescope Technologies for >5 m2 area
  - Light-weight mirrors composition
    - Glass/Composite
    - Thin film (stretch membrane/replicated shells)
  - Structures and latches
    - Deploy/redeploy capability
    - Elastic Memory Composite materials
  - Optical alignment techniques
    - Active vs. Passive
    - Deformable/Correction optics
- Common Telescope Reqt's and Testing
  - Size, Optical Quality, Wavelength Range, Orbits, Operating Temperatures
- Space Validation Needs
  - Nonlinear behavior in zero g environment

Requirements for Light-Weight Deployable UV/Visible/IR Telescopes

Parameter	Resolution DZ [km]	Resolution DX [km]	Accuracy %	Wavelength mm	Tel.Dia. m	Figure	Orbit km/deg
O_3 (trop.)	2.5	200	10	0.3	>3.0	l/1	500-polar
CO_2	3.0	500	0.5	1.6/2.0	>3.0	l/2	500-polar
H_2O	1.0	100	10	0.82/.94	>2.5	l/2	500-polar
NO_2	3.0	200	10	0.44	>3.0	l/2	500-polar
Aerosols*	60 m	1	10	0.3-2.0	>3.0	l/1	500-polar
Winds: (scanning)							
Coherent	.25-1.0	100-300	1 m/s	2.0	>2.0	l/20	500-polar
Direct	.25-1.0	100-300	1 m/s	0.355	>3.0	l/2	500-polar
IR Imaging	---	30-100 m		10-14	>2.5	l/20	GEO, L1, L2

*Done as part of DIAL missions

Essential Technology Elements for Light-Weight Deployable UV/Visible/IR Telescopes

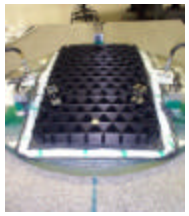
- Advanced Mirror technologies
- Structures
- (Active & Passive) Dynamic controls
- Wavefront sensing
- Integrated control architectures
- System Level Design issues
  - Thermal design , modeling and control
  - Calibration
  - Scanning - pointing reference
- Deployment
  - Deployment and latch actuators, stability of structure, secondary deployment components have high TRL but at the system Level, integrations has low TRL
- System Level Validation Technologies needs
  - Laser systems
  - Detectors/filters

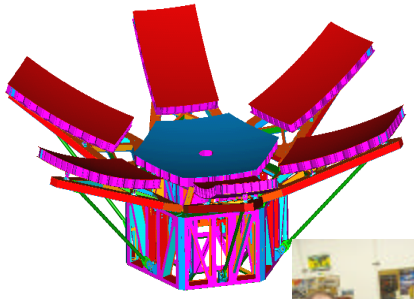
State of the Art for Light-Weight Deployable UV/Visible/IR Telescopes

Technology Development Pipeline

- NMSD Next
- AMSD Advanced
- Actuator
- ~~*Nexus*~~
- Ultra-light test bed (AFRL)
  - Latches and deployment mechanism
  - Deployment concepts
  - Component development
- SBL space based laser AFRL

Illustration of State of the Art





System Level Design issues for Light-Weight Deployable UV/Visible/IR Telescopes

Extensive on-going work associated with NGST and AMSD in deployable telescopes. Unique problems associated with typical LEO - Earth Science missions:

- Thermal cycling effects due to variable solar loading
  - Gradients
  - Day- night
  - Thermal Set
  - Thermal shock in and out of ecilpse
  - GEO pointing close to sun line
- Pointing non inertial reference frame or scene reference complicates attitude control
- Affects the
  - Deployment
  - Calibration image (quality and radiometric and pointing)
  - Maintenance or correction
  - Stability
- Doppler shifts (wavelength calibration)
- LEO Contamination? Atomic O -->applies to any LEO
- Orbit maintenance .. Thruster issues… contamination…control log issues
- Minimize structural mass with Uniform & low CTE across structure w/ good optical surface

Mirror technologies for Light-Weight Deployable UV/Visible/IR Telescopes

Technology	TRL level	areal density
– Composite mirrors	TRL 3	
– Carbon silicon carbide	TRL	
– Glass/composite	TRL	15kg/m^2
– Thin meniscus glass	TRL	15kg/m^2
– Beryllium	TRL	
– Light weighted glass	TRL 3	
– HOE	TRL 1	
– Fresnel lens	TRL 2 -4 (light bucket)	
– Membranes	TRL 1	

* will demonstrate mirror assembly @ 15kg/m2 (by AMSD in CY02)

Targeting for 8 kg/m2 for mirror

- Issues:
  - Manufacturing of blanks, actuators, reaction structures, optical processing
  - Filter coating for laser receivers to reduce heat on mirror
  - Effectively control the mirror in the dynamic thermal environments,

Structure Technologies for Light-Weight Deployable UV/Visible/IR Telescopes

State of the Art for Structures

- Mid-modulus CFRP, based on COI design (open truss)
- USAF/RL MISTI (solid hexagonal frame)
- Multifunctional Structures
  - Power, thermal,
- ISOgrid vs. solid tubular frame
  - Elastic membrane

- Issues:
  - Manufacturing of blanks, actuators, reaction structures, optical processing
  - Potential use of filter coating for laser receivers to reduce heat on mirror
  - Effectively control the mirror in the dynamic thermal environments,

Technology Validation Roadmap for Light-Weight Deployable UV/Visible/IR Telescopes

Concept: Large Deployable Telescope for DIAL LIDAR

- **Science Drivers:**
  - DIAL Lidar for high vertical resolution O_3 and aerosol profiles and simultaneous measurements of total column O_3, CO, and NO_2.
- **Technology Drivers**
  - Mass and optical quality of mirror segments
  - Deployment and phasing of segments
  - Phase stability and maintenance